CLAIMS

1. A method for distance measurement comprising the steps of:

establishing two spatially different points from which a distance is measured or monitored by acoustical measuring devices between each said point and a center of a reflecting area on a target object such that a substantially perpendicular line could be drawn through said first point and said center of said reflecting area on said target, and an angled line could be drawn through said second point and said center of said reflecting area on said target, thereby these two lines and a line drawn through said two points define a right triangle denoted ΔABC with its hypotenuse denoted CB between said second point and said center of said reflecting area of said target;

measuring an approximate length of a vertical leg AB of said triangle;

measuring an approximate length of said hypotenuse CB of said triangle; and

obtaining a distance defined, between the said first point and said center of said reflecting area on said target through the application of the functional relationship between said distance and a ratio between the approximate length of said vertical leg AB of said triangle and the approximate length of said hypotenuse CB of said triangle, whereby said distance measurement is invariant to changes in the speed of sound propagation through the medium.

2. The method according to claim 1 further including the steps of:

obtaining said distance by implementing a computation of the following formula: $h = w \cdot tg[arcsin(L_{AB}/L_{CB})]$, wherein w represents the known distance between the vertical leg AB and said second point, and L_{AB} denotes measured length of said vertical leg AB of said triangle ΔABC, and L_{CB} denotes measured length of said hypotenuse CB of said triangle ΔABC, and h represents the distance.

3. The method according to claim 2 wherein in the Pulse Transit Time-based methods of echo processing in acoustical measuring systems, said formula for the determination of said distance h may have the following mathematical description: $h = w \cdot tg[arcsin(T_1/T_2)]$, wherein T_1 denotes the time that passes while the acoustic pulse train travels from an emitter located at said first point toward the target and back to a receiver located at said first point, and T_2 denotes the time that passes while the acoustic pulse train travels from an emitter located at said second point toward the target and then continue to a receiver associated with said second point.

4. The method according to claim 1 wherein said approach to the exclusion of the speed of sound variable from the outcome of said distance measurement does not depend on the type of acoustical signals traveling through the medium and the type of echo processing used for the monitoring of variables that are proportional to length of said leg AB and length of said hypotenuse CB of said triangle $\triangle ABC$.

5. The method according to claim 1 wherein any method for acoustical echo processing including but not limited to known Pulse Transit Time, FMCW, Phase Shift or Amplitude Change-based methods and their variations are applicable for the monitoring of said L_{AB} and L_{CB} variables.

6. The method according to claim 5 wherein selection of said method for echo processing is determined by a specification of the technical project said method of the present invention is applied for.

7. The method according to claim 1 wherein said approximate length of said vertical leg AB and said approximate length of said hypotenuse CB are approximate due to variations in the speed of sound.

8. The method according to claim 1 wherein said target is moving.

9. The method according to claim 1 wherein said target is substantially stationary.

10. The method according to claim 1 wherein said method is used for the distance measurement from both sides of said target object.

11. The method according to claim 10 wherein thickness of said target object is calculated by application of a delta math paradigm such that $\theta = D - (d_1 + d_2)$, wherein

θ denotes thickness of said target object, D denotes a predetermined constant base distance between emitters at said first points situated coaxially from both sides of said target object, d_1 denotes distance between one said first point and one side of said target object, and d_2 denotes distance between another first point and the opposite side of said target object.

12. The method according to claim 11 further including a step of:

calculating said distances d_1 and d_2 according to the formula:

$\forall \, j = 1,2 \Rightarrow d_j = w_j \cdot tg[arcsin(L_{AB,j}/L_{CB,j})]$ wherein j denotes the side of said target object from which the distance is being measured, and w_j denotes a predetermined known length of the leg AC_j of said triangle $\triangle ABC_j$ established at j-th site of said target object, and $L_{AB,j}$ denotes an approximate length of the leg AB_j of said triangle $\triangle ABC_j$ and $L_{CB,j}$ denotes an approximate length of the hypotenuse CB_j of said triangle $\triangle ABC_j$.

13. The method according to claim 1 wherein said target object is flat.

14. The method according to claim 13 wherein said approximate length of said vertical leg AB and said approximate length of said hypotenuse CB are approximate due to variations in the speed of sound.

15.   An apparatus implementing said method, comprising:

a first distance measuring assembly having a first emitter of acoustic energy and a first receiver of acoustic energy located in substantially same spatial region with defining a first point;

a second distance measuring assembly having a second emitter of acoustic energy located in a second spatial region defining a second point and having a second receiver of acoustic energy substantially symmetrically associated with said second point; and

means for calculation of a distance between said first point and an instant center of a reflecting area on a target object.

16. The apparatus according to claim 15 wherein:

said first assembly sends and receives signals along a perpendicular axis to said reflecting area on said target; and

said second assembly sends and receives signals along an angled axis to said reflecting area on said target, whereby the direction of said first assembly's gradient of emitted acoustical energy and the direction of said second assembly's gradient of emitted acoustical energy and a line drawn through said first point and said second point create a right triangle denoted ΔABC with its hypotenuse denoted CB between the second assembly's emitter and the instant center of the target's reflecting area; and

a vertex A of said triangle ΔABC is a projection of said second point onto said line AB; and

said second point is a vertex B of said triangle ΔABC; and

the output of said first assembly's receiver is connected to a first input of said means for precise distance calculation; and

the output of said second assembly's receiver is connected to a second input of said means for precise distance calculation, thereby facilitating the ability of said means for precise distance calculating to process data from both said measuring assemblies and to calculate said sought distance; and

the output of said means for precise distance calculation is connected to an input of said means for delivering said distance measurement outcome to an accepting device or a user.

17. The apparatus according to claim 15 wherein:

said first assembly measures an approximate length of the vertical leg of said triangle denoted L_{AB} and sends its measurement to said means for calculating said sought distance h;

said second assembly measures an approximate length of the hypotenuse CB of the triangle denoted L_{CB} and sends its measurement to said means for calculating said sought distance h; and

said means for calculating a precise value of said distance h through the application of the functional relationship between the sought distance h and the ratio L_{AB}/L_{CB}, whereby improving the accuracy, resolution and operating speed of said sought distance h measurement due to the invariance of the measurement outcome to changes in the speed of sound propagation through the medium.

18. The apparatus according to claim 15 wherein:

said means for calculation is a computing device programmed to numerically calculate said sought distance.

19. The apparatus according to claim 15 wherein said means for distance-calculation is an electronic digital and/or analog device which structural organization allows generation of an electronic signal proportional to said sought distance.

20. The apparatus according to claim 15 further including:

in thickness measurement applications for a flat material, moving or immobile, a thickness-measuring gauge is comprised of two said distance measuring apparatus, each of said apparatus implementing the method of the present invention, with one said apparatus mounted on a frame above the material and another said apparatus mounted on the same frame underneath the material; and

both said apparatus are situated coaxially such that the acoustic beams from both apparatus aim at the same point from the both sides of said material.

21. The apparatus according to claim 20 wherein:

the thickness of said flat material is calculated by application of a delta math paradigm such that $\theta = D - (d_1 + d_2)$ wherein

θ denotes thickness of said material, and D denotes a predetermined constant base distance between two opposing each other points on said frame and d_1 denotes said measured by said first apparatus precise distance between said opposing point on the frame and one side of said flat material, and d_2 denotes said measured by said second apparatus precise distance between another said opposing point and the opposite side of said flat material, whereby providing for improvement in said thickness measurement accuracy, resolution and operating speed due to the exclusion of the speed of sound variable from the acoustical process of distance measurement.

22. The apparatus according to claim 15 further comprises:
means for delivering said distance measurement outcome to an accepting device or a user.